FMRI During Stimulus Correlated Motion and Overt Subject Responses Using a Single Trial Paradigm

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Purpose. To demonstrate that reliable BOLD contrast FMRI images can be obtained in the presence of overt subject responses and other brief stimulus correlated motion, such as swallowing, movement of the jaw, tongue, or facial muscles, by using a single-trial paradigm.

Introduction. Blood oxygenation level dependant functional magnetic resonance imaging (BOLD-FMRI) has become an important tool in recent years in the study of the neuronal control of a variety of tasks. However, even slight movement or changes in the magnetic field have been shown to give rise to stimulus correlated motion artifacts, impeding the study of tasks requiring overt responses or involving significant subject motion. (1,2) Here we present a technique that overcomes this limitation and enables the acquisition of functional MR images in the presence of these stimulus correlated motions.

The basis of this technique is that the signal intensity changes resulting from neuronal activation are delayed in time due to the slow hemodynamic response. In contrast to this, signal changes resulting from motion occur almost instantaneously. By using a single trial paradigm (3), it is possible to separate in time the signal changes due to motion and the changes due to hemodynamic responses.

Methods. A series of axial and sagittal T2* weighted echo-planar images were acquired during various tasks involving stimulus correlated motion – speaking, swallowing, jaw, tongue, and lip movement – using both a traditional block style and a single trial stimulus paradigm. All scans were performed on a Bruker Biospec 3T/60 magnet. (TR/TE = 1000ms/27.2ms, 10mm slice thickness, 24cm FOV, 64x64).
Block Trial Paradigm: Imaging runs in the block trial paradigm followed an "on-off" pattern of activity, alternating 15 seconds of task with 15 seconds of rest, repeated 5 times for a total of 150 images. Data were analyzed by correlating the pixel time-series with a delayed boxcar reference function.
Single Trial Paradigm: For each task assessed using the single-trial paradigm, the subject performed the activity briefly (e.g. one swallow, speaking one word) every 15 seconds for 20 repetitions. The images from all twenty 15-second epochs were then averaged together to produce one 15-second averaged "response time course." For the swallowing task, the large image phase changes resulting from the motion were used to temporally align the images prior to averaging. For the other tasks the nominal timing was used to control this averaging. Data were analyzed by identifying pixels exhibiting the characteristics of the hemodynamic impulse response and correlating it with every other pixel time-course. The first few images occurring during the motion were not used in this correlation.

Results. The block-trial paradigm identified activated regions of the motor cortex for all of the tasks, but also contained large regions of false activation near the edge of the brain caused by the movement and magnetic field changes related to the stimulus correlated motion. The single trial paradigm more clearly identified activated regions and did not contain the artifacts seen in the block trial. Pixel time-courses in the single trial design indicated large spikes in the first few images corresponding to the motion. Pixels in "activated" regions had a slight delay from task performance and a slow rise and fall consistent with the BOLD effect.

Discussion. Stimulus correlated motion artifacts caused by speaking, swallowing, or other movements associated with the task are avoided in the single trial paradigm since signal changes arising from motion and neuronal activation are separated in time. By ignoring the first time points in the averaged time course, which occur during the motion, regions with similar hemodynamic responses can be identified.

The ability to obtain functional activation maps in the presence of stimulus correlated motions, especially overt vocal responses, allows for a greater variety of neuro-psychological tests to be performed with FMRI and increases the flexibility of current protocols.

References:

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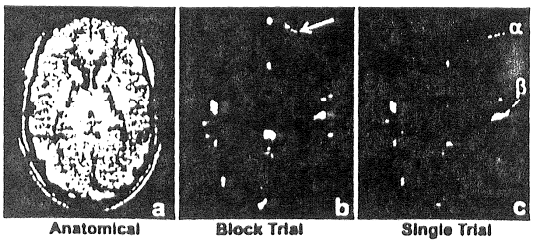

Figure 1: (a) axial anatomical brain image (b) functional image of speaking words out loud using block-trials. Note artifact at edge (arrow) (c) functional image of the same task using single trial paradigm. Artifact is no longer present (α).

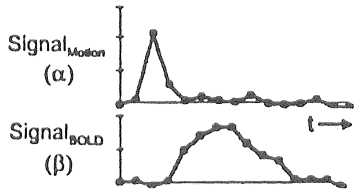

Figure2: (top) pixel intensity of time course of a pixel at the edge (α in Fig. 1) of the brain corrupted by motion. (bottom) pixel intensity of averaged time course from pixel in a region showing a characteristic BOLD response (β in Fig. 1)

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